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NEW YORK CENTER FOR
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SUMMARY

Environmental measurements were taken to assess the effectiveness of a dust control method used in dairy farming operations during the chopping of bedding materials for cows. This work was done in response to a technical assistance request from the New York Center For Agricultural Medicine and Health (NYCAMH). Environmental measurements were taken during four days of sampling, February 5-8, 1991, at eight different dairy barns near Cooperstown, NY. Samples were collected to measure airborne concentrations of total dust, inhalable dust, endotoxins, histamine, viable bacteria and viable fungi. Airborne particle size distributions were measured and bulk samples of hay were analyzed for the viable fungi, viable bacteria, and moisture content. Bedding chopping operations were sampled at each barn using both wet and dry hay to evaluate the effectiveness of the use of water in controlling dust and bioaerosol concentrations. Sampling was conducted both with and without the addition of 1 quart of water to the cut side of bedding hay/straw prior to chopping. Bedding chopping operations are generally performed for a period of less than 45 minutes each day at these barns.

The average personal exposure to inhalable dust during dry chopping operations was 11.31 milligrams per cubic meter of air (mg/m^3) with a standard deviation (STD) of 7.88. The average exposure measurements from wet chopping operations was 2.76 mg/m^3 with a STD of 2.43. The average area inhalable dust concentration from dry chopping was 11.08 mg/m^3 with a STD of 7.64. The wet chopping operations had an average concentration of 2.65 mg/m^3 with a STD of 1.75. The 8 area total dust samples collected during dry chopping operations had an average concentration of 17.11 mg/m^3 with a STD of 5.08. Samples collected during wet chopping were lower with an average concentration of 3.04 mg/m^3 and a STD of 1.97. When calculated as an 8-hour time-weighted average, all sample measurements were well below environmental criteria for total dust exposure.

Endotoxin concentrations found on personal inhalable dust samples during dry sampling conditions had an average of 5,968 endotoxin units per cubic meter of air (EU/m^3) with a STD of 5,396. The samples from wet chopping operations had lower endotoxin concentrations with an average of 1,260 EU/m^3 and a STD of 1,786. The average area endotoxin concentration from dry chopping was 5,569 EU/m^3 with a STD of 5,463 and an average concentration of 1,600 EU/m^3 with a STD of 3,144 during wet chopping operations. Samples collected with total dust samplers during dry chopping operations had an average concentration of 40,547 EU/m^3 with a STD of 46,879. During wet chopping the average concentration was 4,205 EU/m^3 and a STD of 6,013.

The fungal concentrations incubated on RBS agar averaged $6.1x10^6$ colony forming units per cubic meter of air (CFU/m^3) in dry conditions and $4.9x10^5$ CFU/m^3 in wet conditions. Fungal samples incubated on DG18 agar had an average of $8.1x10^6$ CFU/m^3 for dry conditions and $2.6x10^6$ CFU/m^3 for wet conditions. Gram-negative bacterial concentrations from dry chopping had an average of $2.1x10^7$ CFU/m^3; concentrations from wet chopping had an average of $3.4x10^6$ CFU/m^3. Total mesophilic bacterial concentrations were $2.3x10^7$ CFU/m^3 for dry chopping and $4.9x10^6$ CFU/m^3 for wet chopping conditions.

Wet chopping reduced significantly the concentrations of airborne dusts, endotoxins, viable fungi, mesophilic bacteria, and gram-negative bacteria in the dairy barns we surveyed. When used, this control practice may greatly reduce farm exposures during bedding chopping operations. Significant bioaerosol concentrations were measured in some barns during wet chopping and additional controls may be needed in these barns, as well as others, pending the quality of the hay used for chopping.

Key Words: SIC 0241 (Dairy Farms), bedding chopping, organic dusts, fungi, bacteria, endotoxins.

INTRODUCTION

Environmental measurements were taken to assess the effectiveness of a dust control method used in dairy farming operations during the chopping of bedding materials for cows. These measurements were taken during four days of sampling, February 5-8, 1991, at eight different dairy farms near Cooperstown NY. Samples were collected to measure airborne concentrations of total dust, inhalable dust, endotoxins, histamine, viable bacteria and viable fungi. Airborne particle size distributions were measured and bulk samples of hay were analyzed for the viable fungi, viable bacteria, and moisture content. This work was done in conjunction with The New York Center For Agricultural Medicine and Health (NYCAMH) in response to their request (RDHETA 91-097).

BACKGROUND

Bedding choppers are used by many farmers in the Cooperstown, NY area to chop hay/straw to be used as bedding for dairy cows. Square bales of hay are put into the bedding chopper and chopped into smaller pieces by the mechanical action of rotating blades. The bedding chopper is generally operated along a central walkway inside the dairy barn to fill each stanchion with bedding. The materials used for bedding are usually hay or straw that is of poorer quality than feed material. Often the hay used for bedding is hay that has become wet at some point during harvest or storage and contains higher concentrations of microorganisms making it unsuitable for feed.

In 1986, NIOSH investigators worked with scientists from NYCAMH to evaluate dust exposures from bedding chopping. This study showed that the operation of a bedding chopper can produce high concentrations of organic dusts containing bacteria, fungi, and endotoxins.[1] NYCAMH scientists learned of a practice used by some area dairy farmers to control dust emissions from bedding choppers. This practice involved the addition of small quantities of water (approximately 1-2 pints of water per bale) to the "cut side" of a bale of hay* prior to chopping. This practice reduced visible quantities of dusts in air; however there was no data to quantify any reduction in airborne dust concentrations.

METHODS

Air samples were collected to assess the effectiveness of water applied to hay bales in reducing airborne dust concentrations during bedding chopping. Eight different barns were sampled over a four day period. NYCAMH coordinated both the selection and scheduling of farms for this study. Bedding chopping operations were sampled at each barn with and without the addition of water to hay bales. The sampling schedule is listed below:

DATE	BARN	CHOPPING CONDITION
2/5/91	Barns 1 - 4	Dry - No Water Added
2/6/91	Barns 1 - 4	Wet - Water Added

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* When hay is baled in square bales the straws are packed parallel to one another with a cut side (or base) of the straw shaft exposed on one side of the bale. This orientation permits the rapid uptake of water applied to this side and its distribution throughout the bale.

2/7/91	Barns 5 - 8	Dry - No Water Added
2/8/91	Barns 5 - 8	Wet - Water Added

One quart of water was added to each bale of hay/straw for the operations sampled wet. The bale was positioned with the cut side up and water was added to this side approximately ten minutes prior to chopping. The farmers were asked to use hay or straw from the same cutting to ensure hay materials of similar composition were used during both wet and dry sampling trials.

Samples were collected to measure airborne concentrations of total dust, inhalable dust, endotoxins, histamine, viable fungi, and viable bacteria during dry and wet chopping operations. Airborne particle size distributions were measured and bulk samples of hay were analyzed for the viable fungi, viable bacteria, and moisture content. Table 1 provides details on the sampling methods used during this survey. Table 1a lists laboratory methods employed for viable microorganisms.

Personal inhalable dust samples were collected from the farmer operating the bedding chopper at each barn. These samples were collected by attaching the sampler to the farmer and positioning the sampling inlet in the farmer's breathing zone. Samples were also collected from three sampling stations inside each barn. Two of the sampling stations (Stations 1 and 2) were stationary, positioned at separate points in the chopping path. Sampling station 3 was carried throughout the chopping cycle and positioned near the farmer.

Matched Pair t-Tests were used to statistically evaluate differences in dust and endotoxin concentration between the chopping of dry and wet bedding materials. Differences in the concentration of viable bacteria and fungi under the two chopping conditions were examined with Wilcoxon Signed-Rank Tests.[2]

ENVIRONMENTAL CRITERIA

As a guide to the evaluation of the hazard posed by workplace exposures, NIOSH field staff employ environmental evaluations criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienist' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that

industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

The OSHA Permissible Exposure Limit (PEL) for total dust exposure to hay (classified under the category of "particulate not otherwise regulated") is a TWA of 15 mg of dust per cubic meter of air (mg/m^3) over an 8-hour period. ACGIH has established an 8-hour TLV of 10 mg/m^3 for total dust. NIOSH has no recommended exposure criteria for such particulates. Currently, no environmental exposure criteria exist for bioaerosol exposures.

RESULTS/DISCUSSION

The addition of small quantities of water to the "cut side" of a hay bale was an effective way to distribute moisture throughout the bale. This is likely a result of the parallel arrangement of the straws in the bale . Shortly after the application of water, moisture could be detected beneath the bale. The percent-by-weight moisture content of hay materials gathered after chopping operations is presented below:

	MOISTURE CONTENT(%)	
BARN	DRY HAY	WET HAY
BN 1	8.5	29.6
BN 2	8.4	15.5
BN 3	25.7	35.5
BN 4	8.6	8.4
BN 5	30.2	33.5
BN 6	44.3	37.7
BN 7	38.8	24.0
BN 8	25.0	25.8

The concentrations of fungi, gram-negative bacteria, and total mesophilic bacteria were not significantly different in the wet and dry bulk hay samples. Table 2 lists fungal concentrations in bulk hay. Fungi grown on RBS media had an average concentration of $3.1x10^6$ colony forming units per gram of hay (CFU/g) in the dry samples and $2.6x10^6$ CFU/g in the wet hay samples. Fungi were also plated and grown on a second media, DG18. DG18 is a medium designed by food microbiologists for the detection of xerophilic fungi - fungi that prefer the somewhat lower water activities characteristic of grain storage conditions. The average fungal concentration from samples grown on DG18 media was $3.9x10^6$ CFU/g for dry samples and $3.5x10^6$ CFU/g for wet hay samples. Bacterial concentrations from bulk hay samples are presented in Tables 3 and 4. The average mesophilic bacterial concentration from dry samples was $5.9x10^7$ CFU/g and $5.8x10^7$ CFU/g in the wet samples. Gram-negative bacterial concentrations in dry samples had an average of $3.1x10^7$ CFU/g and $2.7x10^7$ CFU/g in the wet samples. These data suggest that the hay samples used for the dry and wet chopping operations had similar bacterial and fungal concentrations.

The addition of water to hay bales prior to chopping substantially reduced dust concentrations in air. Table 5 presents the inhalable dust concentrations from personal exposure measurements. The average personal exposure measurement from dry chopping operations was 11.31 milligrams

per cubic meter (mg/m^3) with a standard deviation (STD) of 7.88. The average exposure measurement from wet chopping operations was 2.76 mg/m^3 with a STD of 2.43. Table 6 presents the area dust concentrations measured at the three barn sampling stations using an inhalable sampling inlet. Twenty-two samples are reported for dry sampling conditions and 24 samples are reported for wet sampling conditions. The average dust concentration from dry chopping was 11.08 mg/m^3 with a STD of 7.64. The wet chopping operations had an average concentration of 2.65 mg/m^3 with a STD of 1.75. These reductions in dust concentrations during wet chopping operations were statistically significant ($p = 0.0001$).

Table 7 presents the dust concentrations measured using high volume total dust samplers. The 8 samples collected during dry chopping operations had an average concentration of 17.11 mg/m^3 with a STD of 5.08. Samples collected during wet chopping were lower with an average concentration of 3.04 mg/m^3 and a STD of 1.97. These reductions in dust concentrations during wet chopping were statistically significant ($p = 0.0003$). These concentrations were measured during the relatively short durations of bedding chopping operations that take place once a day at these barns. When the time-weighted averages were calculated for an 8-hour period, all were found to be well below the OSHA PEL and the ACGIH TLV for total dust.

Figures 1 and 2 provide respectively the average values and direct reading measurements from the Miniram aerosol monitor. As with the gravimetric analysis, both illustrate the effectiveness of water treatment in reducing dust levels in all barns.

Figure 3 provides the size distribution data for impactor samples collected during both dry and wet treatments. The dry data points are averages from barns 2, 6, and 8, while the wet observations are from a single measurement in barn 3. Note that most of the impactor samples collected during the wet treatment had insufficient dust loading for accurate analysis. The distributions are reasonably similar however, and indicate a mass media aerodynamic diameter in the range of 10-15um.

The dust in these barns was a complex mixture of principally organic materials. Figure 4 is a photomicrograph of a settled dust sample collected in barn 3 which shows the presence of fungal spores, fragments of hyphea and starch particles.

Table 5 presents the endotoxin concentrations from personal inhalable dust samples. The 7 samples reported for dry sampling conditions had an average of 5,968 endotoxin units per cubic meter of air (EU/m^3) with a STD of 5,396. The samples from wet chopping operations had lower endotoxin concentrations with an average of 1,260 EU/m^3 and a STD of 1,786. Table 6 presents the endotoxin concentrations measured at the three barn sampling stations using an inhalable sampling inlet. Twenty-two samples are reported for dry sampling conditions and 24 for wet sampling conditions. The average endotoxin concentration from dry chopping was 5,569 EU/m^3 with a STD of 5,463. The wet chopping operations had an average concentration of 1,600 EU/m^3 with a STD of 3,144. These reductions in endotoxin concentrations during wet chopping operations were statistically significant ($p = 0.005$).

Table 7 presents the endotoxin concentrations measured using high volume total dust samplers. The 8 samples collected during dry chopping operations had an average concentration of 40,547 EU/m^3 with a STD of 46,879. Samples collected during wet chopping were lower with an average concentration of 4,205 EU/m^3 and a STD of 6,013. These reductions in endotoxin concentrations during wet chopping were statistically significant ($p = 0.04$).

Table 8 presents the sampling data for viable fungi and bacteria in air.** The values presented for each barn are the average of two viable samples collected at two separate sampling stations (Stations 1 and 2). The viable mesophilic fungal samples during wet chopping conditions were lower than those collected during the dry conditions. The fungal concentrations incubated on RBS agar had a mean of $6.1x10^6$ CFU/m^3 for dry conditions and $4.9x10^5$ CFU/m^3 for wet conditions. Fungal samples incubated on DG18 agar had a mean of $8.1x10^6$ CFU/m^3 for dry conditions and $2.6x10^6$ CFU/m^3 for wet conditions. These reductions in viable fungal concentrations during wet chopping were statistically significant ($p = 0.02$). Average bacterial concentrations were also lower during wet chopping. Gram-negative bacterial concentrations from dry chopping had a mean of $2.1x10^7$ CFU/m^3; concentrations from wet chopping had a mean of $3.4x10^6$ CFU/m^3.

Total mesophilic bacterial concentrations were $2.3x10^7$ CFU/m^3 for dry chopping and $4.9x10^6$ CFU/m^3 for wet chopping conditions. The reductions in viable Gram-negative bacteria and total mesophilic bacteria during wet chopping were statistically significant ($p = 0.02$).

Table 10 presents a statistical summary for the air sampling data contrasting the wet and dry chopping methods.

Histamine was assayed from airborne dust samples from each of the barns. The air histamine concentrations dropped significantly in all the barns except barn #6 as shown in Table 9. The number of filters without detectable histamine levels was 4/39 from the dry hay and 20/39 from the wet hay. Histamine content of bulk hay was also assayed and ranged from 0.078 to 125.75 nanomoles per milligram of hay (nm/mg). The average was 11.45 ± 31.06 nm/mg bulk hay. Histamine content from the aerosolized dust from filters with detectable dust and histamine levels was 116.74 ± 346.17 nm/mg dust.

CONCLUSIONS

The addition of 1 quart of water to the cut side of bedding hay/straw prior to chopping proved a simple and effective method of reducing airborne concentrations of dusts and bioaerosols. Wet chopping reduced significantly the concentrations of airborne dusts, endotoxins, viable fungi, and Gram-negative bacteria in the dairy barns we surveyed. When used, this control practice may greatly reduce farm exposures during bedding chopping operations. Bioaerosol concentrations were high in some barns during wet chopping and additional controls may be needed at these farms, as well as at others pending the quality of the hay used for chopping. Wet hay worked satisfactorily for chopping at all dairy farms except farm 8 where an older bedding chopper was used; wet chopping operations at farm 8 were a problem due to frequent blockage of the bedding chopper by the wet hay. With the exception of farm 8, the use of wet chopping methods did not have major effects on the labor or burden associated with bedding chopping.

** Some particulate adhered to the polycarbonate filters used for viable sampling and was not removed during washing. Consequently, the concentrations of viable organisms may be higher than reported.

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Table 1

New York Center for Agricultural Medicine and Health
Cooperstown, NY
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Industrial Hygiene Sampling Methods

Analyte	Sampling Media	Sampler	Flow Rate	Sample Type*	Analytical Method(s)	Methods Reference
Inhalable Dust	25mm Mixed Copolymer Filter Type DM-800	Inhalable Inlet	2.0 lpm	P/A	1. Gravimetric Analysis 2. Endotoxin Analysis (KLAL)	3,4,5
Total Dust	1. 37mm Mixed Copolymer Filter Type DM-800	Open-Faced Filter Cassette	10.6 lpm	A	1. Gravimetric Analysis 2. Endotoxin Analysis (KLAL) 3. Histamine (RIA)	4,5
	2	Miniram Direct Reading Aerosol Monitor		A	Direct Reading	
Particle Size Distributions	Glass fiber collection Media	Impactor	2.0 lpm	A	1. Gravimetric Analysis	6
Viable Microorganisms	Polycarbonate Filter	Total Dust Inlet	2.0 lpm	A	Enumeration and Identification of Bacteria and Fungi Through Dilution Plating on Nutrient Agar	7,8,9

*P - Personal Breathing Zone Sample, A - Area Sample
lpm - Liters per minute
mm - millimeter

Table 1a

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HETA 91-097

Laboratory Methods Employed for Viable Microorganisms

Organism	Media	Incubation Temperature (°C)
Mesophilic Fungi	Rose Bengal Streptomycin AGAR (RBS)	25
Mesophilic Fungi	DG18	25
Gram-Negative Bacteria	Eosin Methylene Blue AGAR (EMB)	36
Mesophilic Bacteria	Tryptic Soy AGAR	36

Table 2

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Cooperstown, NY
HETA 91-097

FUNGAL CONCENTRATIONS IN BULK HAY SAMPLES
COLONY FORMING UNITS PER GRAM (CFU/g)

BARN	CFU/g DRY SAMPLES	WET SAMPLES
BN 1	1.6×10^6	1.3×10^6
BN 2	7.5×10^6	5.4×10^6
BN 3	4.3×10^5	3.6×10^5
BN 4	5.3×10^6	6.7×10^6
BN 5	ND	2.0×10^4
BN 6	1.0×10^5	1.0×10^5
BN 7	1.0×10^7	6.2×10^6
BN 8	2.7×10^4	6.4×10^5
BN 1	1.8×10^6	2.6×10^6
BN 2	3.6×10^6	4.2×10^6
BN 3	1.3×10^6	3.1×10^5
BN 4	2.2×10^7	1.6×10^7
BN 5	ND	1.7×10^4
BN 6	1.0×10^5	1.1×10^5
BN 7	2.2×10^6	4.2×10^6
BN 8	4.7×10^4	8.9×10^5

STATISTICAL SUMMARY

	CHOPPING CONDITION	SAMPLES	MEAN	STANDARD DEVIATION
RBS	DRY	8	3.1×10^6	4.0×10^6
RBS	WET	8	2.6×10^6	3.0×10^6
DG18	DRY	8	3.9×10^6	7.4×10^6
DG18	WET	8	3.5×10^6	5.3×10^6

Table 3

New York Center for Agricultural Medicine and Health
Cooperstown, NY
HETA 91-097

MESOPHILIC BACTERIAL CONCENTRATIONS IN BULK HAY SAMPLES
COLONY FORMING UNITS PER GRAM (CFU/g)

	CFU/g	
BARN	DRY SAMPLES	WET SAMPLES
BN 1	9.1×10^7	6.6×10^7
BN 2	8.2×10^7	1.2×10^8
BN 3	1.5×10^7	5.9×10^6
BN 4	1.5×10^7	2.0×10^7
BN 5	2.8×10^4	7.3×10^5
BN 6	9.6×10^6	2.2×10^7
BN 7	2.6×10^8	2.1×10^8
BN 8	1.7×10^5	1.6×10^7

STATISTICAL SUMMARY

CHOPPING CONDITION	SAMPLES	MEAN	STANDARD DEVIATION
DRY	8	5.9×10^7	8.9×10^7
WET	8	5.8×10^7	7.3×10^7

Table 4

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GRAM - NEGATIVE BACTERIAL CONCENTRATIONS IN BULK HAY SAMPLES
COLONY FORMING UNITS PER GRAM (CFU/g)

	CFU/g	
BARN	DRY SAMPLES	WET SAMPLES
BN 1	1.8×10^7	1.4×10^7
BN 2	7.6×10^7	6.8×10^7
BN 3	1.2×10^7	4.6×10^6
BN 4	1.4×10^7	2.0×10^7
BN 5	1.0×10^6	4.2×10^5
BN 6	8.4×10^6	1.8×10^7
BN 7	1.2×10^8	6.4×10^7
BN 8	7.7×10^5	2.4×10^7

STATISTICAL SUMMARY

CHOPPING CONDITION	SAMPLES	MEAN	STANDARD DEVIATION
DRY	8	3.1×10^7	4.3×10^7
WET	8	2.7×10^7	2.6×10^7

Table 5

New York Center for Agricultural Medicine and Health
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INHALABLE DUST AND ENDOTOXIN EXPOSURES IN AIR

	DUST CONCENTRATION (mg/m³)		ENDOTOXIN CONCENTRATION (EU/m³)	
BARN	DRY	WET	DRY	WET
BN 1	1.84	1.67	987	97
BN 2	8.83	8.11	13,855	5,279
BN 3	20.22	1.85	7,949	394
BN 4	6.32	4.00	2,099	1,016
BN 5	6.39	0.35	1,810	49
BN 6	25.00	2.93	12,366	2,211
BN 7	14.32	2.12	VOID	1,033
BN 8	7.54	1.09	2,712	ND

Personal Breathing Zone Samples

mg/m³ - milligram of dust per cubic meter of air

EU/m³ - Endotoxin units per cubic meter of air

Table 6

New York Center for Agricultural Medicine and Health
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AIRBORNE DUST AND ENDOTOXIN SAMPLES COLLECTED USING AN INHALABLE INLET

BARN	SAMPLING STATION	CONDITION	CONCENTRATION DUST (mg/m^3)	CONCENTRATION ENDOTOXIN (EU/m^3)
BN 1	1	DRY	33.23	11,594
BN 1	2	DRY	9.68	2,432
BN 1	3	DRY	VOID	VOID
BN 1	1	WET	2.14	1,005
BN 1	2	WET	1.79	670
BN 1	3	WET	6.43	729
BN 2	1	DRY	VOID	VOID
BN 2	2	DRY	10.32	8,669
BN 2	3	DRY	10.83	7,448
BN 2	1	WET	3.06	3,117
BN 2	2	WET	1.89	1,222
BN 2	3	WET	8.06	10,634
BN 3	1	DRY	7.40	1,975
BN 3	2	DRY	11.25	3,255
BN 3	3	DRY	10.65	6,726
BN 3	1	WET	3.52	466
BN 3	2	WET	5.56	597
BN 3	3	WET	2.78	162
BN 4	1	DRY	18.95	11,530
BN 4	2	DRY	20.29	20,772
BN 4	3	DRY	8.89	1,442
BN 4	1	WET	1.11	462
BN 4	2	WET	1.32	455
BN 4	3	WET	1.32	74
BN 5	1	DRY	3.46	419
BN 5	2	DRY	4.62	194
BN 5	3	DRY	3.85	496
BN 5	1	WET	1.49	52
BN 5	2	WET	1.87	170
BN 5	3	WET	2.61	289

Table 6 (Continued)

New York Center for Agricultural Medicine and Health
Cooperstown, NY
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AIRBORNE DUST AND ENDOTOXIN SAMPLES COLLECTED USING AN INHALABLE INLET

BARN	SAMPLING STATION	CONDITION	CONCENTRATION DUST (mg/m^3)	CONCENTRATION ENDOTOXIN (EU/m^3)
BN 6	1	DRY	15.00	1,215
BN 6	2	DRY	20.00	16,233
BN 6	3	DRY	18.61	4,601
BN 6	1	WET	2.13	92
BN 6	2	WET	2.69	1,210
BN 6	3	WET	1.06	56
BN 7	1	DRY	11.32	1,480
BN 7	2	DRY	1.84	2,171
BN 7	3	DRY	12.90	4,539
BN 7	1	WET	2.33	297
BN 7	2	WET	1.06	36
BN 7	3	WET	2.54	255
BN 8	1	DRY	2.81	7,093
BN 8	2	DRY	5.37	6,709
BN 8	3	DRY	2.54	1,518
BN 8	1	WET	3.48	1,603
BN 8	2	WET	1.98	12,294
BN 8	3	WET	1.32	2,465

mg/m^3 - milligrams of dust per cubic meter of air

EU/m^3 - Endotoxin units per cubic meter of air

Table 7

New York Center for Agricultural Medicine and Health
Cooperstown, NY
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CONCENTRATIONS OF TOTAL DUST AND ENDOTOXIN IN AIR

	DUST CONCENTRATION (mg/m^3)		ENDOTOXIN CONCENTRATION (EU/m^3)	
BARN	DRY	WET	DRY	WET
BN 1	15.28	1.95	29,148	674
BN 2	23.77	5.42	115,033	18,082
BN 3	12.04	5.45	9,623	3,354
BN 4	19.71	1.05	46,177	797
BN 5	11.76	3.52	2,431	1,084
BN 6	22.59	0.05	6,709	1,255
BN 7	11.47	4.16	- 5,015	1,259
BN 8	20.30	2.75	110,240	7,137

Table 8

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Cooperstown, NY
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VIABLE FUNGAL AND BACTERIAL CONCENTRATIONS IN AIR

FUNGI

FUNGAL CONCENTRATION (CFU/m^3)

BARN	RBS AGAR DRY	RBS AGAR WET	DG18 AGAR DRY	DG18 AGAR WET
BN 1	8.8×10^6	7.8×10^5	9.8×10^6	2.4×10^6
BN 2	2.2×10^6	3.0×10^5	4.2×10^6	3.1×10^6
BN 3	1.0×10^6	2.1×10^5	7.6×10^6	1.1×10^6
BN 4	3.4×10^7	1.5×10^6	3.8×10^7	1.5×10^7
BN 5	6.6×10^5	4.0×10^4	8.1×10^5	7.5×10^4
BN 6	7.6×10^5	8.4×10^4	5.6×10^5	1.6×10^5
BN 7	5.7×10^5	2.9×10^5	9.8×10^5	3.6×10^5
BN 8	1.2×10^6	7.4×10^5	2.9×10^6	1.2×10^6

BACTERIA

BACTERIAL CONCENTRATIONS (CFU/m^3)

BARN	TOTAL MESOPHILIC BACTERIA (TSA AGAR) DRY	TOTAL MESOPHILIC BACTERIA (TSA AGAR) WET	GRAM - NEGATIVE BACTERIA (EMB AGAR) DRY	GRAM - NEGATIVE BACTERIA (EMB AGAR) WET
BN 1	1.7×10^8	3.5×10^7	1.6×10^8	2.5×10^7
BN 2	4.3×10^6	9.9×10^5	3.0×10^6	5.8×10^5
BN 3	3.3×10^6	7.7×10^5	1.6×10^6	4.7×10^5
BN 4	4.7×10^6	5.8×10^5	2.9×10^6	2.7×10^5
BN 5	3.6×10^5	2.7×10^5	1.5×10^5	1.8×10^5
BN 6	1.1×10^6	5.8×10^5	6.8×10^5	5.4×10^5
BN 7	2.1×10^6	7.2×10^5	1.3×10^6	2.9×10^5
BN 8	8.0×10^5	5.3×10^5	7.2×10^5	5.9×10^4

CFU/m^3 - Colony Forming units per cubic meter

Table 9

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AIR HISTAMINE CONCENTRATION*

Barn	Dry (S.D.)	Wet (S.D.)
BN1	0.179 (0.178)	0.0096 (0.021)
BN2	0.349 (0.313)	0.087 (0.066)
BN3	0.464 (0.276)	0.214 (0.181)
BN4	0.605 (0.262)	0.0045 (0.0057)
BN5	0.854 (0.964)	0.0 (0.0)
BN6	0.297 (0.132)	0.269 (0.394)
BN7	0.147 (0.121)	0.056 (0.051)
BN8	2.269 (4.55)	0.0096 (0.0214)
Average	0.655 (1.66)	0.0467 (0.064)

*ng/m³

Table 10

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STATISTICAL SUMMARY OF AIR SAMPLING RESULTS

ANALYTE	CONDITION	SAMPLES	MEAN	STANDARD DEVIATION
TOTAL DUST	DRY	8	17.11 mg/m³	5.08
	WET	8	3.04 mg/m³	1.97
ENDOTOXINS IN TOTAL DUST	DRY	8	40,547 EU/m³	46,879
	WET	8	4,205 EU/m³	6,013
PERSONAL INHALABLE DUST	DRY	8	11.31 mg/m³	7.88
	WET	8	2.76 mg/m³	2.43
PERSONAL INHALABLE ENDOTOXINS	DRY	7	5,968 EU/m³	5,396
	WET	8	1,260 EU/m³	1,786
AREA INHALABLE INLET DUST SAMPLES	DRY	22	11.08 mg/m³	7.64
	WET	24	2.65 mg/m³	1.75
ENDOTOXIN IN INHALABLE INLET SAMPLES	DRY	22	5,569 EU/m³	5,463
	WET	24	1,600 EU/m³	3,144
VIABLE FUNGI (RBS AGAR)	DRY	8*	6.1×10^4 CFU/m³	1.2×10^7
	WET	8*	4.9×10^3 CFU/m³	4.9×10^5
VIABLE FUNGI (DG18 AGAR)	DRY	8	8.1×10^4 CFU/m³	1.3×10^7
	WET	8	2.6×10^4 CFU/m³	5.1×10^6
GRAM - NEGATIVE BACTERIA	DRY	8*	2.1×10^7 CFU/m³	5.6×10^7
	WET	8*	3.4×10^4 CFU/m³	8.7×10^4
TOTAL MESOPHILIC BACTERIA	DRY	8*	2.3×10^7 CFU/m³	5.9×10^7
	WET	8*	4.9×10^4 CFU/m³	1.2×10^7

* The average of 2 viable samples collected at each barn was used as the sample value/da point for each of the 8 barns sampled.

FIGURE 1
AVERAGE MINIRAM VALUES FOR EACH BARN

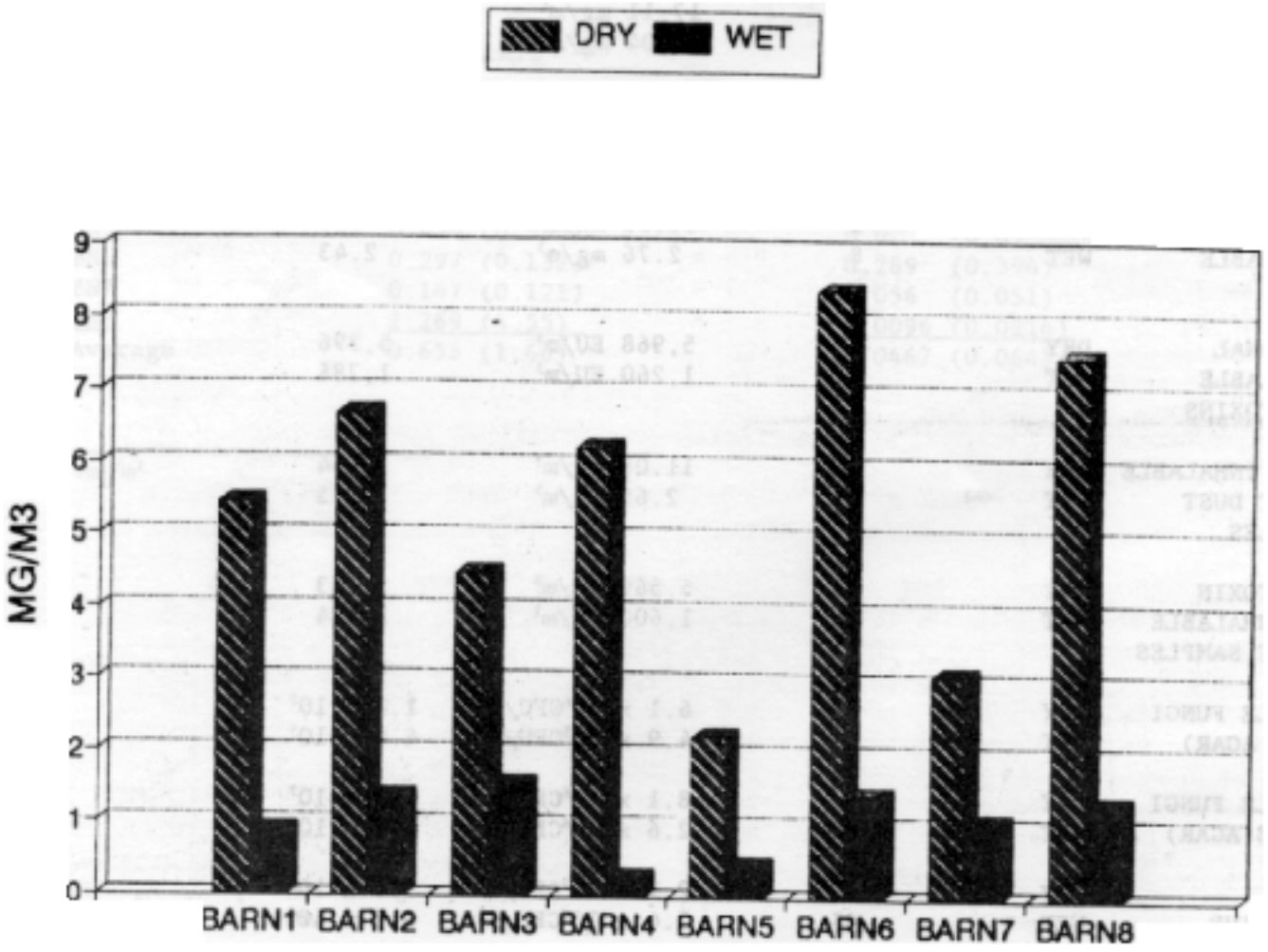

FIGURE 2
DIRECT READING MINIRAM MEASUREMENTS

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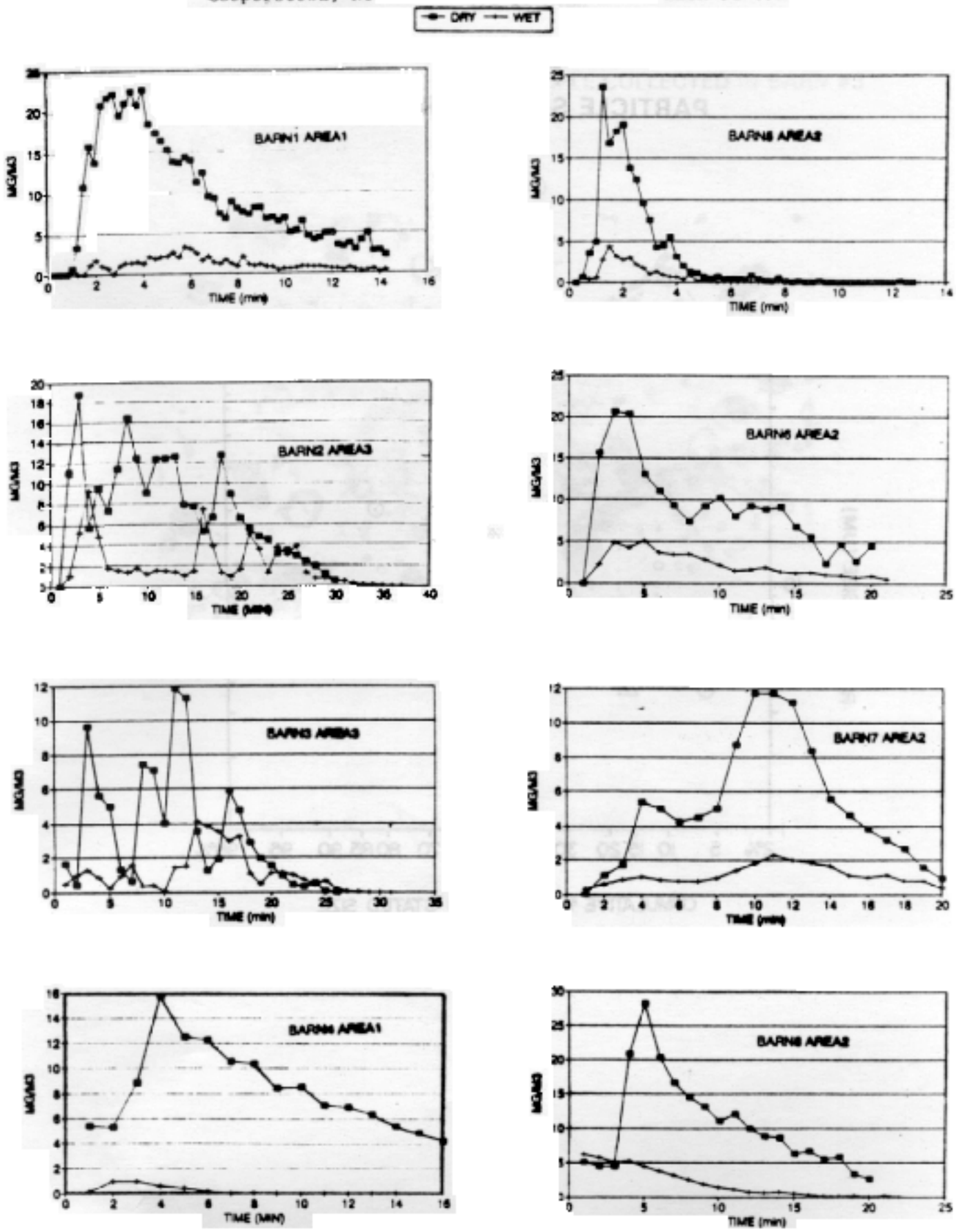

FIGURE 3
PARTICLE SIZE DISTRIBUTIONS

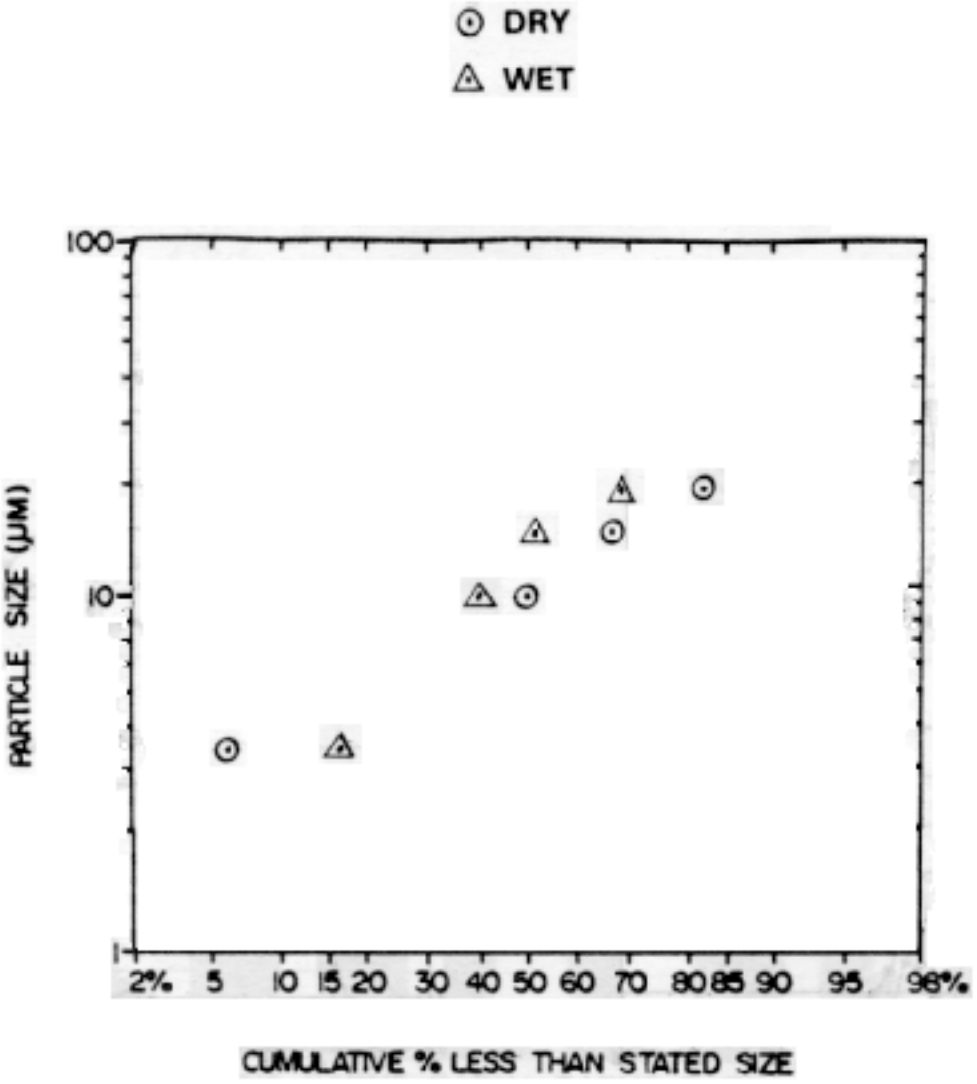

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FIGURE 4
PHOTOMICROGRAPH OF SETTLED DUST SAMPLE COLLECTED IN BARN #3